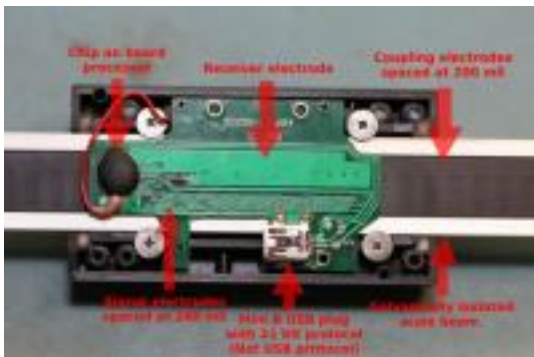


21 Bit Protocol Scales

Introduction



A company named [iGaging](#) has introduced a new series of [digital scales](#) that rivals the affordability of Chinese import scales from Harbor Freight, Shars, and other sources. They come in lengths from 6 inches up to 35 inches. ShumaTech performed a technical assessment of these scales and is pleased to report that we were able to adapt the [DRO-550](#) and [DPU-550](#) running [OpenDRO](#) for use with these scales. A picture of a iGaging model 35-706 6" digital scale is shown at left along with its included remote LCD readout. If you are interested in purchasing iGaging scales, you can find them at [Grizzly Industrial](#), [Amazon](#), [Eagle America](#), and several other on-line stores. ShumaTech is not affiliated with any of these stores.



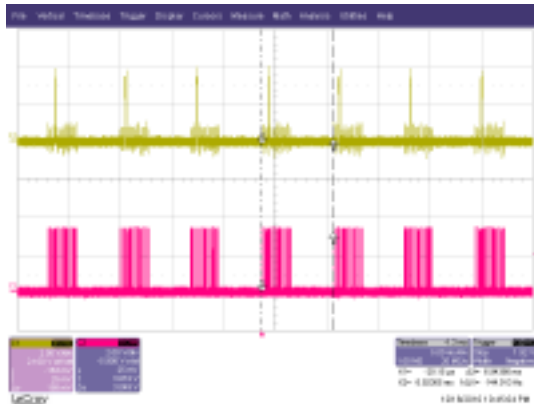
The internals of the iGaging scales reveal that this scale is based on the same capacitive design as the Chinese import scales. The iGaging scales are in fact made in China too. The capacitive design was originally developed by Sylvac in the early 1980's. The scale internals pictured at left reveal the same 200 mil placement of coupling electrodes on the scale beam along with the eight signal electrodes repeating every 200 mils. The large receiver electrode that is capacitively coupled to the signal electrodes via the coupling electrodes in the scale beam is found on top. If the reader is interested in more technical details on the capacitive scales, lots of information can be found in [patent 4420754](#) and other patents that reference it.

One other interesting attribute of these scales is that like all other Chinese scales, the beam is conductive and connected to the battery. In the case of the iGaging scales, the beam is connected to the negative side of the battery. This means that if you mix iGaging scales with 24 bit or BCD7 scales that have their scale beams connected to the positive side of the battery, then you must galvanically isolate one scale type or the

other. If you don't, then the power supply on the DRO will be shorted and will shut down until the short is removed.

The connector on the circuit board is a [USB mini B](#) female but beware that the protocol is NOT USB as we will show on the next page. Plugging these scales into a USB port on a PC could damage them. The cable that connects the scale to the remote LCD readout is a standard USB mini B male to USB mini B male. The remote LCD readout provides several functions such as metric/inch conversion, zeroing, and fractions. It also supplies 3V power from two coin cell batteries to the scale. Note that the readout is not necessary to read the position from the scales since all capacitive processing and digital interface circuitry is on the scale PCB.

21 Bit Protocol



Probing the remote LCD readout's USB connector with a voltmeter indicates that pin 1 is connected to the positive side of the battery (3V) and that pin 4 is connected to the negative side of the battery (ground). A capture with an oscilloscope with the scale in operation connected to the remote LCD readout reveals 3V single-ended digital signals are present on pins 2 (red trace) and 3 (yellow trace). The signals occur in repetitive bursts that repeat approximately every 7 milliseconds or at a frequency of 143 Hz.

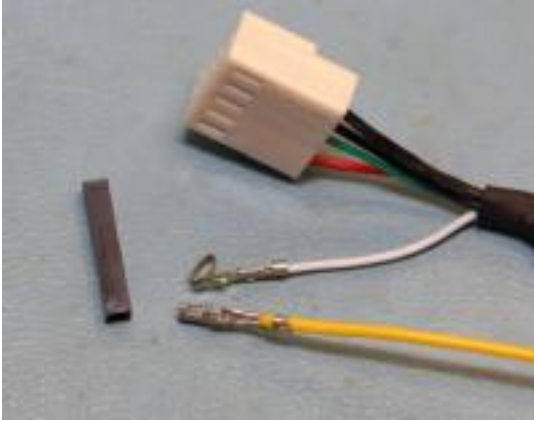
Zooming in on one of the bursts shows the signal in more detail. There are 21 clock pulses on the red trace (pin 2) and a digital signal on the yellow trace (pin 3). By using our previous knowledge of Chinese scales, we can guess that the signal is a synchronous serial signal that gives the scale's position in binary with the least significant bit (LSB) first. This guess turns out to be correct. The Chinese scales send two 24 bit binary values with one being the absolute position and the other being the relative position each expressed as 20480 counts per inch (CPI). Given that we have a single 21 bit value, we can also guess that the single 21 bit value sent by the scale is an absolute position with 3 bits less precision to yield 2560 CPI ($20480 / 2^3$). Again, this guess turns out to be correct.

The last thing to determine is the source and speed of the clock signal. The oscilloscope trace shown at left gives us a clock speed of about 9 kHz which is much slower than a Chinese scale at around 90 kHz. In most [synchronous serial](#) protocols, the entity that provides the clock is designated the master and the one that receives the clock is the slave. For Chinese protocols, the scale provides the clock so it is the master. By disconnecting the iGaging scale from the remote LCD readout, we find that the remote LCD readout is providing the clock so the scale is a slave. This difference means that the DRO/DPU-550 with OpenDRO must provide an appropriate clock to the scale if it takes the place of the remote LCD readout.

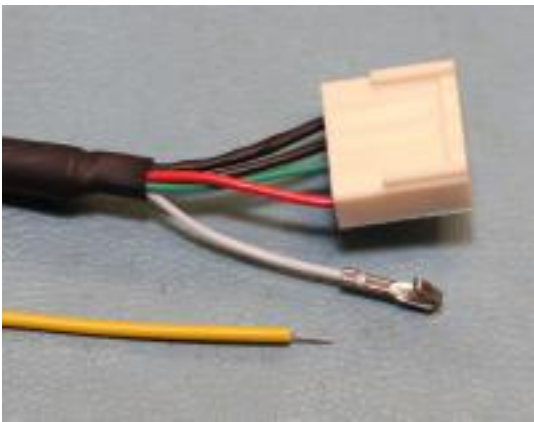
Scale Cable Kit



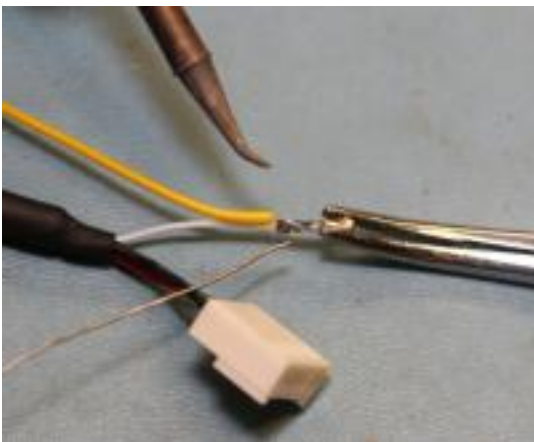
ShumaTech offers a [21 bit scale cable kit](#) that enables the DRO-550 to use the iGaging scales. The cable kit comes with a USB mini B female cable, two jumper wires, two 100 mil headers, and a piece of heat shrink tubing. The USB cable mounts to the back panel of the DRO-550 and is environmentally sealed with a rubber O-ring. A picture of the USB side of the cable is shown at left.



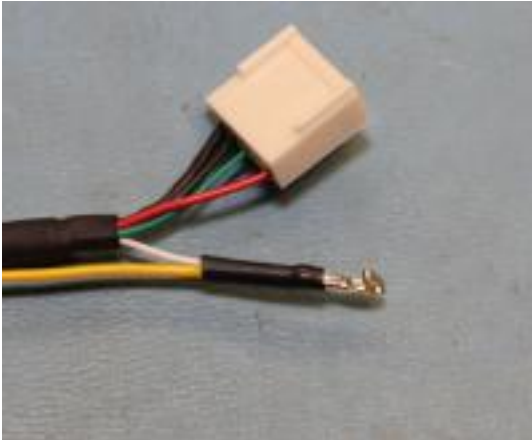
The other end of the USB cable terminates with a standard 100 mil plug with 5 pins. The extra fifth pin is a shield connection and is not used for the DRO-550. To install the cable kit, first remove the housing from one side of the yellow jumper. Next, remove the white pin from the 5 pin plug. Both jobs are easy if you press the small locking clips out of the way with a small flat head screwdriver or a hobby knife.



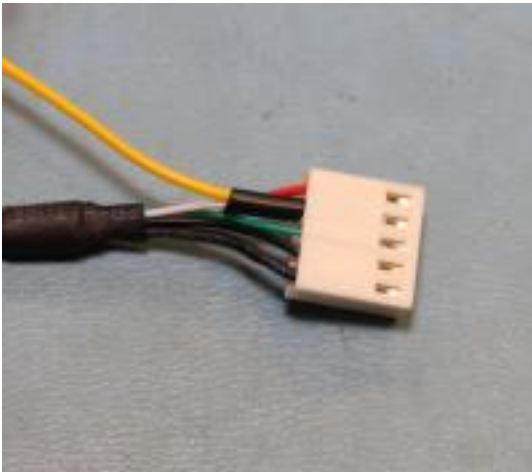
The next step is to cut off the terminal from the yellow jumper cable end whose housing we just removed. Cut it as close as possible to the terminal to give maximum reach inside the DRO when it is installed. Strip off about 1/8" (3mm) of insulation from the cut end.



Take the stripped end of the jumper cable and solder it to the terminal of the white wire removed from the five pin plug. This is easiest to do from the back side of the terminal with the spring tab pointing down. That way the insulation of the white wire does not interfere with the solder flow. Use some solder flux first if you have it. Try to be sparing with the solder otherwise the terminal may be difficult to insert when we are done. At the same time, don't use so little solder that you end up with a poor solder joint. A pair of forceps (as show in the picture) or some helping hands can really assist you with holding the terminal and wire while you solder. Inspect your work with a magnifying glass to make sure that the joint is shiny and solid.

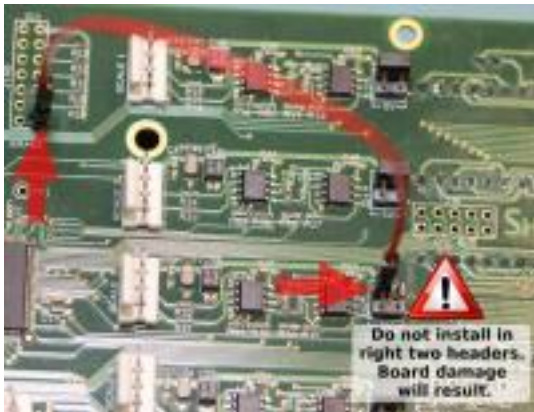
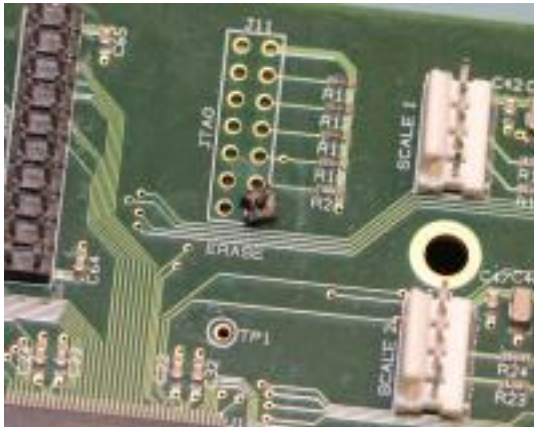


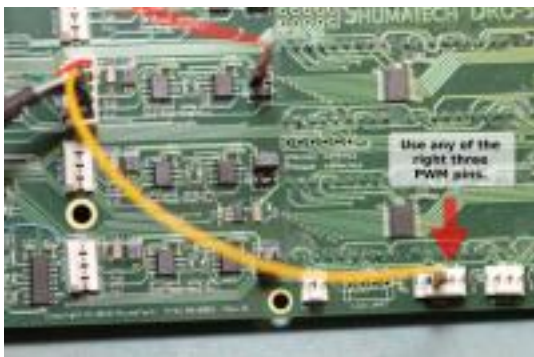
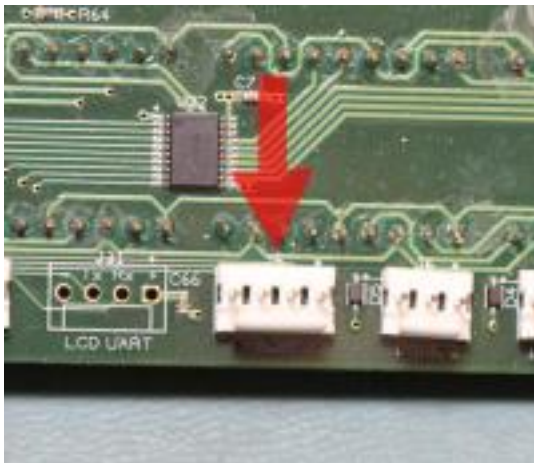
The last step is to place the included piece of heat shrink tubing over the terminal and onto the soldered connection. This helps to stress relief the connection so that it doesn't crack or break loose while installing the cable. Use a heat gun or other heat source to shrink the heat shrink onto the joint.



Insert the spliced connection back into the five pin plug. The spring tab on the terminal should be pointed away from the small rectangular window on the five pin plug. A tiny clip on the back side of the terminal should engage with the window when the terminal is insert all of the way to the front. You may have to squeeze the terminal joint and heat shrink a little with some pliers in order to get it to fit in the plug.

DRO-550 Cable Installation





DPU-550: PROCEED TO THE NEXT SECTION

The iGaging scales need around 3V to operate. The DRO-550 scale interface was designed to operate at either 5V for quadrature scales or at 1.5V for Chinese scales. Thankfully, the DRO-550 processor uses 3.3V so we can supply the scales with that through the scale voltage selection jumper. In order to do that, we must find a suitable location to solder a one pin header so that we can jumper the 3.3V over to the scale interface. There are three 100 mil header locations on the DRO-550 that we can use to solder the one pin header included in the scale cable kit. Two of the locations are on the JTAG header J11 at pins 1 and 13. If you do not plan to develop software for the DRO-550, then the JTAG header on pin 1 is the best place and is what we will show. An alternative is on pin 1 of the UART debug header at J21. This is not the best location because it is the location that we use for the [UART voltage rework](#) but may be the only

alternative if you plan to debug with JTAG.

Once the location is selected, solder the one pin header into the hole from the back side of the DRO-550 PCB. You may want to remove the black key caps around the location of the hole so that you do not melt them with the soldering iron since they are spaced close together. Be careful when removing and reinstalling the key caps to avoid breaking the black tabs that hold them in place.

Now pick the scale input that you want to install the cable for. You can use any one of the five scale inputs you wish and there is no difference in using one over the other since they can be easily remapped to axes in OpenDRO's setup. Remove the black jumper from the scale voltage header for the scale input you selected. Use the red jumper and connect one side to the one pin header you installed in the previous step and the other end to one of the LEFT two pins on the scale voltage header. You can use the second pin on the left to daisy-chain to additional scale voltage headers if you want more than one iGaging scale on your system. Under any circumstance do not jumper onto the right two pins because that will short the power supplies together and bad things could happen.

Take the four pin header included in the scale cable kit and solder it in place at position J5 in the lower right portion of the PCB. This position is also marked PWM underneath it. Hold the header with a finger and tack solder one pin to hold the header in place. Lay the board down and finish soldering the other three pins and return to the fourth pin you tack soldered to clean it up.

Now get the finished USB cable and install the five pin plug onto the four pin scale header. How do you install a five pin plug on a four pin header you ask? Easy, just hang the fifth pin with the cable shield over the side of the scale header. The cable shield is the black wire on one side of the plug. Take a look at the picture at left to confirm the orientation.

Plug the yellow jumper you soldered to the USB scale cable and install it any of the RIGHT three pins on the four pin header you previously soldered in place at J5. The left-most pin is a ground. OpenDRO generates a clock signal that is appropriate for the iGaging scales and outputs it on all three PWM outputs. Without this clock, the iGaging scales will not generate an output signal for the DRO to read.

The final step is to install the USB side of the cable on the back panel of the DRO-550. Pick any location you like as long as it is without obstructions underneath it and is close enough for the cable to reach the scale input. Drill a 5/8" (16mm) hole and install the scale cable by securing it with the plastic nut. The rubber O-ring goes on the outside underneath the lip of the connector to provide a seal.